

“How to Build a Balsawood Bridge”

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What is the challenge?

Teams should construct balsa wood bridges ahead of time to be load tested on the day of the event. *All bridges must meet the following specifications to be tested and eligible for awards:*

- All bridges must contain a truss design element. (See p. 7)
- All bridges must meet Dimensional Parameters and Testing Parameters (See p. 1-2)
- Only the provided balsawood materials should be used in the construction of the bridge. The use of additional glue, or different glue, is permitted.

How are bridges evaluated and prizes awarded?

Four awards (1st, 2nd, 3rd, and 4th Place) will be given in two divisions (Junior, Grades 4-8 or Senior, Grades 9-12) to the team with the highest score determined from the **Bridge Efficiency (E)**. Bridge Efficiency (E) is a ratio of how much load the bridge can handle to the mass of the bridge.

Efficiency of your bridge will be determined using the following formula:

$$E = \text{Bridge Efficiency} = \frac{(\text{LOAD IN kg}) \times (1000 \text{ grams/kg})}{(\text{MASS OF BRIDGE IN grams})}$$

The load will be measured in kilograms, while the mass of the bridge will be measured in grams.

Example: If your bridge weighed 22 grams, and supported 42 kilograms of weight during the test, you would calculate efficiency as follows:

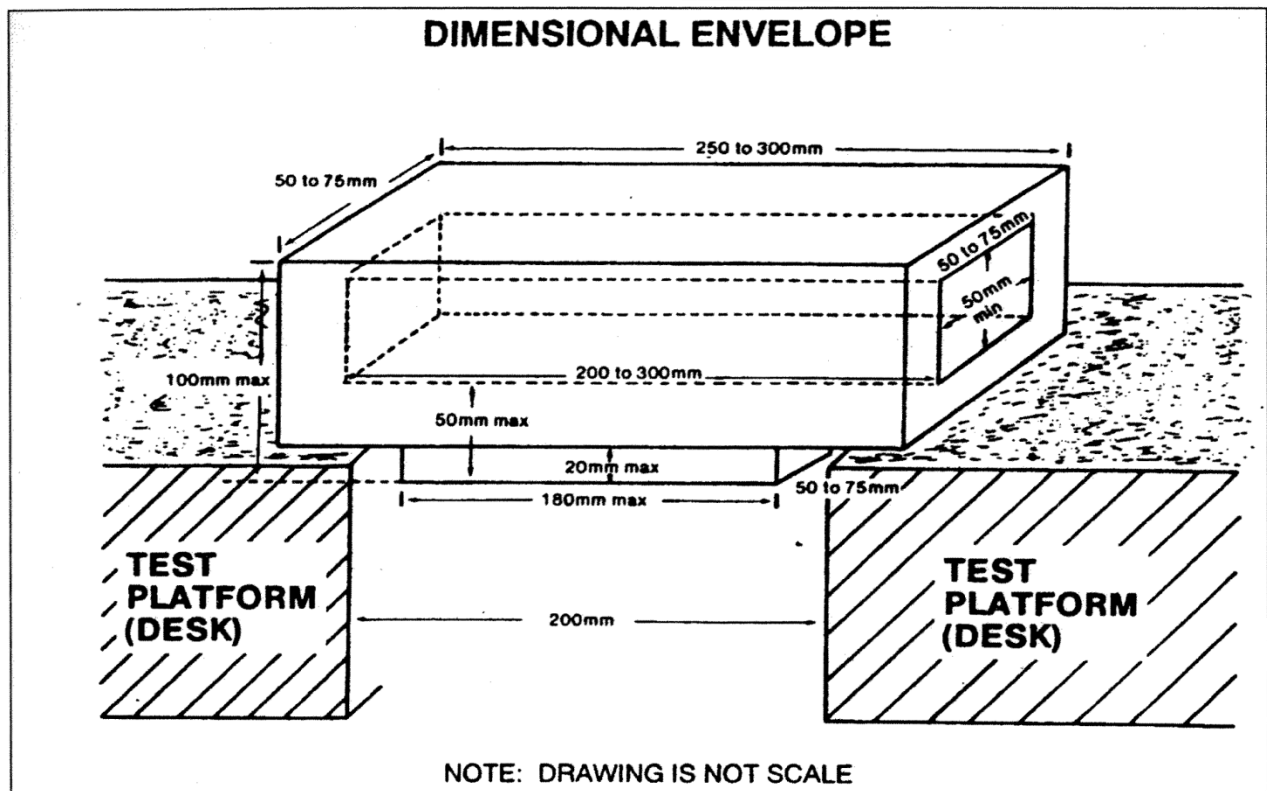
$$E = \text{Bridge Efficiency} = \frac{(\text{LOAD IN kg}) \times (1000 \text{ grams/kg})}{(\text{MASS OF BRIDGE IN grams})} = \frac{(42)(1000)}{(22)} = 1909$$

What are the dimensional parameters required for the bridge?

The bridge must be built within the dimensions in the table below. (A diagram is provided on the next page.) *Bridges not meeting the geometric requirements will not be eligible to compete.* Bridges failing inspection for these parameters may undergo repairs prior to testing in order to meet the dimensional specifications. Only team members are permitted to make alterations to the structure.

	Bridge	Roadbed	Optional Underhang	Testing Platform
Length	250 to 300mm	200 to 300mm	Less than 180mm	50mm
Width	50 to 75mm	50 to 75mm	50 to 75mm	50mm
Height	Less than 100mm	Less than 50mm	Less than 20mm**	7mm

** Included in the overall height of the bridge



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What are the testing parameters required for the bridge?

- Test Block (50mm x 50mm) must be able to *pass through* bridge
- Bridges must have a deck structure to support the test platform. Bridge decks must be accessible to test platforms.
- Bridges shall be loaded only on the bottom of the truss (deck and lower chord)
- Allow space for a 5cm square wooden board to be placed in the center of your bridge. (See Diagrams 1 and 2 for a schematic of the testing platforms.)
 - For *Junior Level (Grades 4-8)* bridges, the load will be applied to this board from beneath the bridge. The hook, illustrated in Diagram 1 (p.5), must be able to pass below the bed where the load device will be connected.
 - For *Senior Level (Grades 9-12)* teams, the load will be applied to the board by a dowel rod placed vertically on top of the bridge deck. Again, make sure your bridge is designed so that the dowel can be **CENTERED** on the bridge deck from above. See Diagram 2 (p. 6).

Is splitting or lamination allowed?

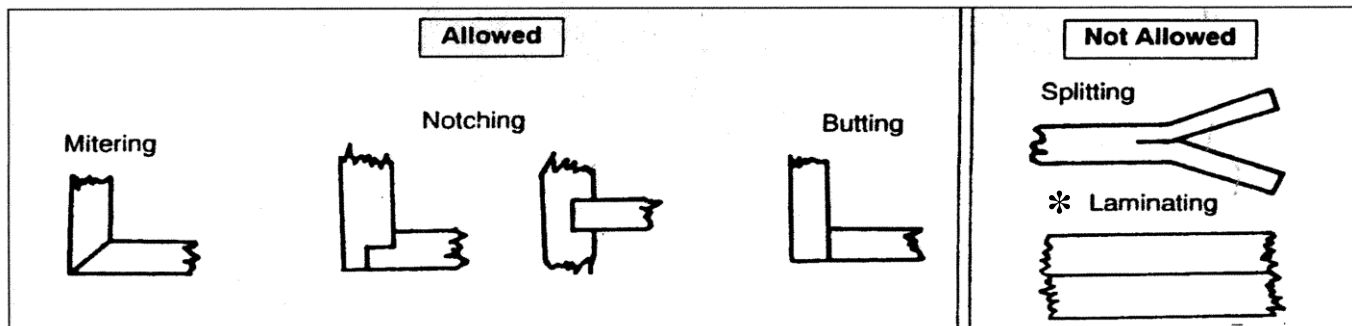
Splitting, or breaking a single piece of wood into multiple pieces, is *not allowed*.

Laminating, defined for the purposes of this competition as bonding (gluing) together multiple pieces of wood parallel to one another to create a larger composite truss member, is allowed only for SENIOR LEVEL teams. Please refer to the diagrams below.

- **No laminating is permitted for JUNIOR LEVEL TEAMS (GRADES 4-8).** Wood pieces may be bonded together with glue only at joints. If two or more strips of wood are placed parallel to each other, they must be at least the thickness of this sheet of paper apart from each other.
- **Laminating is permitted for SENIOR LEVEL (GRADES 9-12) teams ONLY.**

See sketch below for allowed types of connections:

The Following Types of Connections Must be Considered For Your Bridge:



* Lamination of wood pieces is allowed for SENIOR LEVEL teams only.

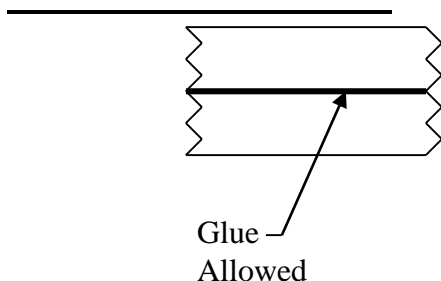


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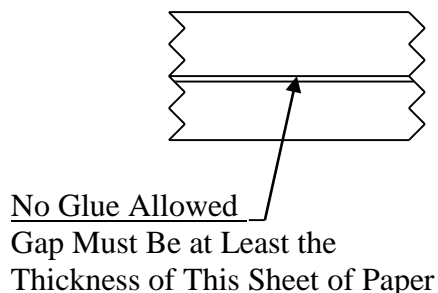
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* Laminating:

Senior Level Teams:



Junior Level Teams:



How do I get started?

Blueprints or plans of the bridge drawn to scale will be very helpful prior to final construction of the bridge. Plans are not required for the competition. Four views should be drawn:

1. END VIEW
2. SIDE VIEW
3. ROADBED
4. TOP VIEW

Recommended Construction Materials & Tools:

- Cardboard for use as a building board
- Straight Pins to hold pieces in place as glue dries
- Single Edge Razor Blade, or X-Acto® knife, for cutting (with adult supervision)
- Waxed Paper, to cover the plan (blueprint) as you build on top of it
- Ruler or other device for measuring
- 15 pieces of balsa wood and a 2/3 oz. bottle of glue (supplied)

Tips for Bridge Construction

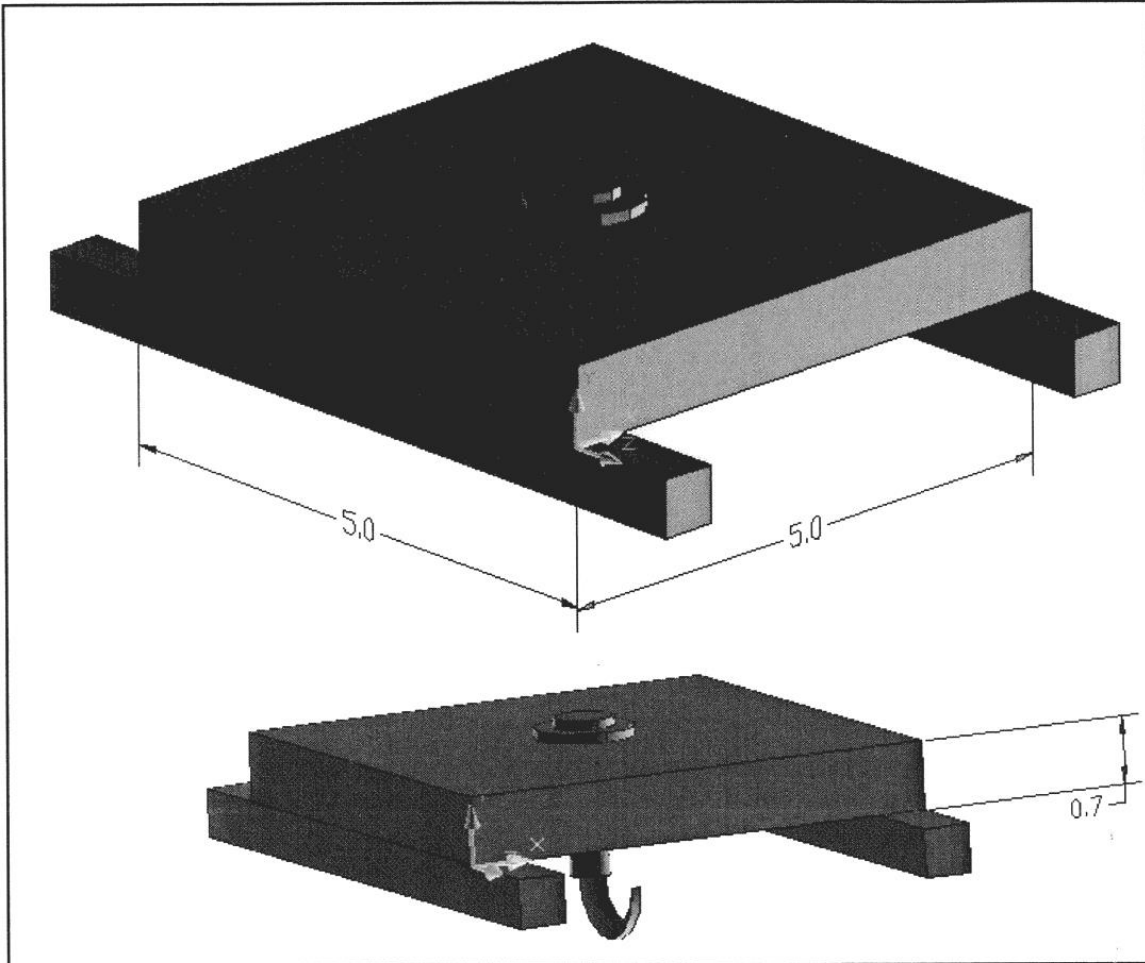
- 1) **Be sure you understand the event rules before designing your prototype.** Revisit the “Dimensional Parameters” and “Testing Parameters” sections of this manual in particular.
- 2) **Draw your preliminary design with full wood outlines.** This should help you to decide whether to use butt joints or lap joints.
- 3) **ALL joints should have absolutely flush surfaces before applying glue.** Anytime glue is used as a "gap filler", it dooms the structure! Cut the wood precisely and carefully sand the part so that it fits flush. Then, number the part and use it as a template to make numbered duplicates in assembly sequence (i.e.: two for bridges, four for towers).
- 4) **Structures are symmetric.** When building a bridge or a tower with two or four sides, build the two primary sides one on top of the other. Once the first side is built, cover it with wax paper and **build the second side directly on top of the first.** This helps insure the structure's symmetric integrity.
- 5) Most competitions require these structures to be weighed. **Up to 20% of the structure's mass may be from over-gluing.** Adhesives do not work better when they are drooled all over the structure. Use the adhesives sparingly where any more than a translucent, moist surface becomes wasted, excess mass.
- 6) When building a balsa wood structure, **pretest all the strips for tensile strength before assembly.** A simple deflection test works best. Anchor half of the strip on a surface and ballast the free end using clay on a bent straight pin. Use a simple gauge to categorize the strips. Group similar tensile strengths together. The strips that deflect the least are the strongest. Use those for the longest pieces. The ones that deflect the most use as the shortest pieces. When the structure is finished, it should have a relatively consistent load carrying capability.

Diagram 1 – JUNIOR LEVEL Test Platform

Sketch of the Testing Platform

(All dimensions in cm)

Note: Figure Not Drawn to Scale



Dimensions of the wooden board:

Length = 50 mm

Width = 50 mm

Height = 7 mm

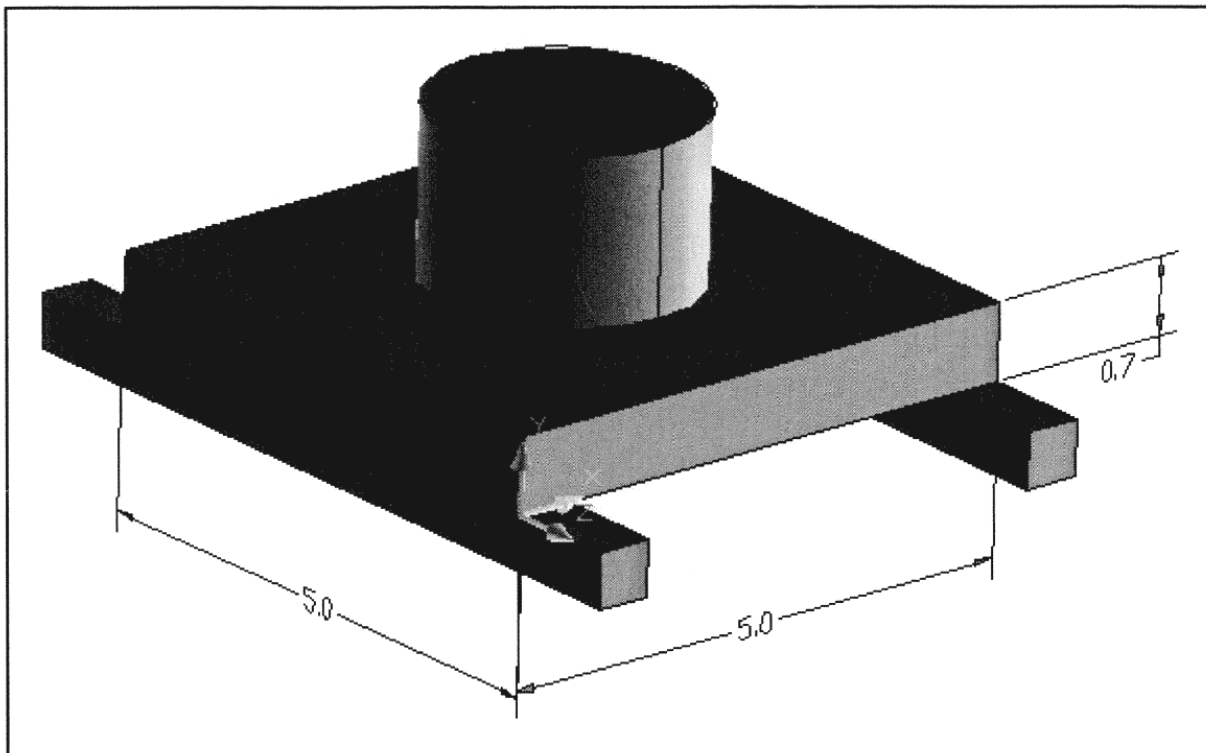
A wooden board has been provided which can be used as a testing platform. The board should be kept at the center of the roadbed on the bridge. The board has been fixed with a hook to which weight will be attached.

Diagram 2 – SENIOR LEVEL Test Platform

Sketch of the Testing Platform

(All dimensions in cm)

Note: Figure Not Drawn to Scale



Dimensions of the wooden board:

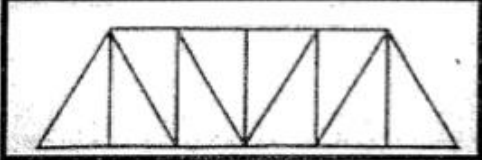
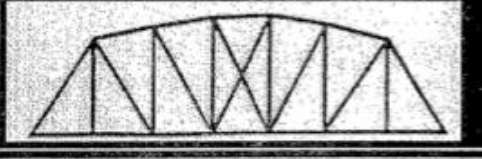
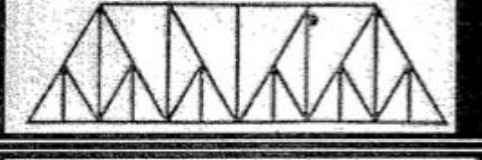

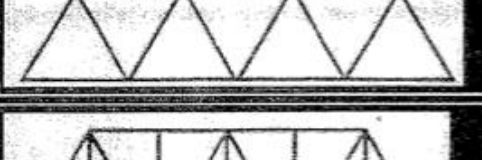
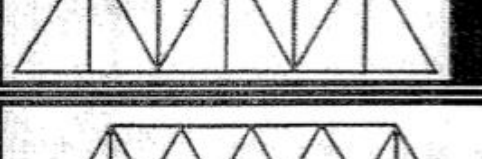
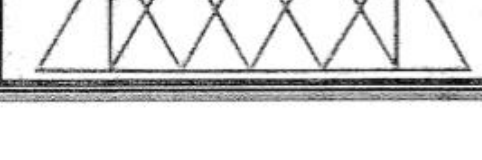
Length = 50 mm

Width = 50 mm

Height = 7 mm

A wooden board has been provided which can be used as a testing platform. The board should be kept at the center of the roadbed on the bridge. Load will be applied from above the board.

Bridge Truss Designs

	PRATT
	CURVED CHORD PRATT
	BALTIMORE
	PENNSYLVANIA(PRATT)
	WARREN W/O VERTICAL SUPPORTS
	WARREN WITH VERTICAL SUPPORTS
	QUADRANGULAR WARREN